The Ups and Downs of J/Ψ Suppression*

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Data from the CERN SPS and the Fermilab fixed target program show that J/ψ production in pA and AB interactions is reduced relative to a linear extrapolation of the pp cross section. Recent claims regarding the production of a new state of matter in Pb+Pb interactions at the CERN SPS illustrate the importance of a thorough understanding of J/ψ production in pA and lighter AB collisions before the strength of the "anomalous" J/ψ suppression in Pb+Pb collisions relative to the Drell-Yan dilepton background can be determined. In these lectures, we begin with a discussion of quarkonium and Drell-Yan production. We then describe the status of J/ψ production in pA interactions with an emphasis on the most recent 800 GeV data. We will then discuss the nucleus-nucleus data and its interpretation in hadronic and phase transition models.

Quarkonium and Drell-Yan production is described by perturbative QCD. If factorization is satisfied, then particle production should be independent of the presence of nuclear matter and σ_{pA} would grow linearly with A for quarkonium and Drell-Yan production. Experimentally, the dependence of perturbative production on atomic mass number A is parameterized by a power law as $\sigma_{pA} = \sigma_{pN} A^{\alpha}$ where σ_{pA} and σ_{pN} are the integrated particle production cross sections in proton-nucleus and proton-nucleon interactions respectively. The integrated Drell-Yan cross section satisfies $\alpha = 1$ to rather high precision. For ψ and Υ production $0.9 < \alpha < 1$.

A wealth of interesting data on charmonium production exists in fixed-target interactions with both proton and nuclear beams. The strong kinematics dependence of the pA data indicates that more than simple absorption by nucleons is taking place. However, the difficulties involved in interpreting the results as a function of x_F arises in part because, so far, shadowing and energy loss effects are not separable due to the way the Drell-Yan data has been incorporated into the shadowing parameterizations. More direct measures of the gluon distribution in the nucleus would help pin down the nuclear parton distributions more precisely without having to rely too strongly on the Drell-Yan data. The importance of intrinsic charm is larger for models where the energy loss is not too high but a small intrinsic charm component of J/ψ production seems to improve the agreement with the data. More data at other energies could provide a means of distinguishing between models.

The interpretation of the present nucleus-nucleus data on J/ψ suppression is also somewhat ambiguous even though most practitioners agree that some novel effect appears in the Pb+Pb data. Whether this is interpreted as increased comover density or as crossing a threshold (like a phase transition would account for), everyone can agree that some effect of high density appears in the Pb+Pb data that is not present in the S+U data. The upcoming NA50 run with target in vacuum will provide better J/ψ data at low E_T than is presently available. This new data will clarify whether or not the peripheral Pb+Pb collisions behave like central and semi-central S+U interactions—a prerequisite for determining the onset of the anomalous suppression. The minimum bias comparison has considerably reduced the statistical uncertainites of the J/ψ suppression data but since the minimum bias analysis is rather model dependent, high statistics Drell-Yan data at large masses should ideally be used. Unfortunately, a very precise Drell-Yan measurement is not likely to be forthcoming from Pb+Pb collisions.

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